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## Soccer Penalty Kick Pre-Impact Cues of Male Right-Footed High School Soccer Players

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The University of Southern Mississippi

SOCCER PENALTY KICK PRE-IMPACT CUES OF MALE  
RIGHT-FOOTED HIGH SCHOOL SOCCER PLAYERS

by

Jason Ryan Jones

Abstract of a Dissertation  
Submitted to the Graduate School  
of The University of Southern Mississippi  
in Partial Fulfillment of the Requirements  
for the Degree of Doctor of Philosophy

May 2010

## ABSTRACT

### SOCCER PENALTY KICK PRE-IMPACT CUES OF MALE RIGHT-FOOTED HIGH SCHOOL SOCCER PLAYERS

by Jason Ryan Jones

May 2010

The purpose of this study was to use direct observation methods to collect evidence of pre-impact cues in a soccer penalty kick and to analyze their predictive powers in determining shot direction. The five pre-impact cues were position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. Video was collected and then analyzed using a Dartfish™ tagging panel. There were a total of fifty male high school right-footed participants. Coaches from area high school soccer teams provided their top penalty kick takers to participate in the study. Video was collected on the team's practice/game site from two vantage points; from the goal line and behind the penalty arch. Logistic regression analysis revealed evidence that the pre-impact cues were effective in predicting shot direction, with the alignment of the hips and the trunk lean significant indicators of shot direction ( $p < .001$ ). Further chi-square analyses of the individual pre-impact cues revealed each was a significant shot direction indicator ( $p < .001$ ).



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## DEDICATION

I would like to dedicate this work to my parents. Thank you both for allowing me to pursue my dreams!

## ACKNOWLEDGEMENTS

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## CHAPTER I

### INTRODUCTION

Soccer is the most popular team sport worldwide. Though it goes by many different names it is often referred to as the “People’s Game” (Sampson, 1999).

Competitive soccer is a low scoring game where outcomes are usually determined by a slight margin of victory. Penalty kicks are often time, the deciding factor in many competitions.

According to soccer’s governing and rule making body, the Federation of International Football Association (FIFA), the penalty kick rule in soccer was established in 1891 to contest the growing use of illegal acts to prevent goals being scored, particularly by handling the ball (Gerhardt, 1979). The soccer penalty kick is something of an oddity when compared to the game itself. It is the only time when the game is stopped and restarted with a one versus one scoring battle. FIFA Law 14 currently states that during a penalty kick the goalkeeper must be on the goal line, facing the kicker, between the posts until the ball is kicked from a distance of 12 yards. The keeper has the ability to move laterally, but must not encroach forward off the line until the ball is struck. The shooter is identified and all players must be at least ten yards from and behind the ball (FIFA, 2009).

FIFA first introduced a penalty kick shoot-out to decide tied matches in the 1982 World Cup. The tie-breaker or penalty kick shoot-out consists of an alternating series of penalty kicks, and is won by the team that has the highest tally of goals after the five kickers have shot. If there is a tie after the five penalty kicks, the shoot-out goes to sudden death giving one shot to each team until there is a winner (McGarry & Franks,

2000). Since then, many competitions and games have been decided this way, such as the National Collegiate Athletic Association (NCAA) championships, Major League Soccer (MLS) championships and World Cup Finals. There have been 41 penalty shootouts and 409 penalty kicks taken in the World Cup, European Championships, and Copa America Games between 1976 and 2004 (Jordet, Hartman, Visscher, & Lemmink, 2007).

On February 20<sup>th</sup> of 2003, Mihoces' article in the USA Today marked stopping a soccer penalty to be number nine on the ten hardest things to do in sports. A goalkeeper facing a penalty kick in a regulation soccer goal, 24 feet wide by eight feet high, requires defending a total of 192 square feet from a ball roughly 9 inches in diameter. Standard ball speed is about 50 mph, a speed which means that it takes the ball only 600 milliseconds (ms) or about half a second to reach the goal line from the instant it is kicked (Kuhn, 1988; Morris & Burwitz, 1989). In contrast, it takes a keeper an average of 660 ms to complete a dive (Morris & Burwitz, 1989), therefore giving goalkeepers a time disadvantage to overcome. Statistics of World Cup penalty kicks show that 76 % of all kicks are successful (Jordet et al., 2007).

In order to perform at the highest level of ability, goalkeepers must use visual information provided by the kickers before the point of impact. To be successful goalkeepers must gather anticipatory pre-impact cues, process the information, and initiate the dive some time before the ball is kicked (Franks, McGarry, & Hanvey, 1999). Pre-impact cues are used in a number of fast ball sports to anticipate outcomes of the motor skill (Abernethy, 1988), allowing for a need to identify and examine pre-impact cues in the soccer penalty kick.

In the existing research, the common variables representing pre-impact cues of the soccer penalty kick are:

- starting position and angle of approach run (Franks, McGarry, & Hanvey, 1999; McMorris, Copeman, Corcoran, Saunders & Potter, 1993; McMorris, Hauxwell & Holder, 1995; Williams & Burwitz, 1993);
- angle and position of the kicking foot at impact (Kim & Lee, 2006; McMorris et al., 1993; McMorris et al., 1995; and Williams & Burwitz, 1993);
- alignment of the hips before impact (Williams & Burwitz, 1993);
- angle and lean of the upper body trunk (Franks et al., 1999; McMorris et al., 1993; and McMorris et al., 1995);
- shoulder zone (Kim & Lee, 2006); and
- non-kicking leg and plant foot (Franks et al., 1999; Kim & Lee, 2006).

The researchers collected the pre-impact cues by using one or a combination of self-reporting questionnaires, visual search patterns, or video edited to different occlusion points. Studies using post-hoc interviews or questionnaires to gather anticipatory cues from the athletes (McMorris et al., 1993; McMorris et al., 1995; Williams & Burwitz, 1993) as a single method of collecting cue information, may contaminate results based on the players' own biases and expectations (Abernethy, 1991). Kim and Lee's (2006) use of an eye movement tracking system to track the gaze patterns of soccer goalkeepers in successful defense of penalty kicks only relates to the athlete's line-of-sight and revealed general information not specifically what the athletes were seeing (Abernethy, 1991). Research using edited film of penalty kicks determined what occlusion points seemed to

be more effective in predicting direction of the penalty kick however the occlusion points were based on self reported cues (Franks et al., 1999; McMorris et al., 1993; McMorris et al., 1995; McMorris & Colenso, 1996;). Although these studies reported valuable information about pre-impact cues in the soccer penalty kick, the methods used to identify these pre-impact cues provide little quantifiable scientific evidence.

Direct (systematic) observation has been used in the study of human behavior in natural settings, including physical activity (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Chow, McKenzie, & Louie, 2008). The fundamental purpose of direct observation is to classify activities into separate categories that can be quantified and analyzed in greater detail. There have been technological advances that allow observational codes to be entered, analyzed, and stored by computers. With the use of digital video cameras, the researcher can obtain observational data and later transfer it to a computer making this methodology very useful and appealing (McKenzie, 2002). Observational studies provide an alternative to a lack of any scientific evidence, providing the researcher acknowledges the associated limitations (Black, 1999). Direct observation of pre-impact cues in soccer penalty kicks is a way to generate data where previous studies only reported information.

#### Significance of the Study

The very nature of low scoring soccer matches and the survival of the tie-breaking penalty kick shoot-outs have boosted the significance of penalty kicks in the game of soccer. Supplying accurate pre-impact cues will give the goalkeeper the ability to predict the shot direction of the penalty kick and allow a better chance to make a save. Coaches



and practitioners can take the significant pre-impact cues of a soccer penalty kick and develop a technical training regimen for blocking penalty kicks.

### Purpose of the Study

The purpose of this study was to use video evidence of soccer penalty kick pre-impact cues in male right-footed high school soccer players to measure their anticipatory value in predicting penalty shot direction. The researcher used direct observation methodologies to collect video from the goalkeepers' point of view. The specific pre-impact cues explored were the position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. The research provided operational definitions of each pre-impact cue and statistical evidence of their anticipatory value.

### Research Questions

1. Are there significant pre-impact cues that determine shot direction of the soccer penalty kick?
2. What does the position of the approach run reveal about shot direction of the soccer penalty kick?
3. What does the Alignment of the hips reveal about shot direction of the soccer penalty kick?
4. What does the lean of the trunk reveal about shot direction of the soccer penalty kick?
5. What does the placement of the non-kicking foot reveal about shot direction of the soccer penalty kick?

6. What does the action of the non-kicking side arm reveal about shot direction of the soccer penalty kick?

#### Null Hypotheses

HO1: There are no significant pre-impact cues that determine shot direction of the soccer penalty kick.

HO2: Position of the approach run will not determine shot direction of the soccer penalty kick.

HO3: Alignment of the hips will not determine shot direction of the soccer penalty kick.

HO4: Trunk lean of the body will not determine shot direction of the soccer penalty kick.

HO5: Placement of the non-kicking foot will not determine shot direction of the soccer penalty kick.

HO6: Action of the non-kicking side arm will not determine shot direction of the soccer penalty kick.

#### Operational Definitions

*Action on the non-kicking side arm* - refers to the position of the kicker's left arm. The measures are taken during the final stages of the approach run coinciding with the last plant foot step. The measures are classified as either up (i.e. quick and deliberate left arm movement extended to the side and hand raised above the waist) or down (i.e. arm stays close to the body and hand remains lower than the waist).

*Position of the approach run* - refers to the kicker's position relative to the ball at the point when the kicker begins to move towards the ball. The measures are classified

as either direct (i.e. within three steps to the left of the ball) or wide (i.e. greater than three steps to the left of the ball).

*Alignment of the hips* - refers to the alignment of the kicker's hips starting just before ball contact and finishing at ball contact. The measures are classified as either open (i.e. hip alignment is not becoming parallel with the goal line) or closed (i.e. hip alignment is or is becoming parallel to goal line).

*Direction of shot* - refers to the side of the goal where the ball crosses the goal line. The measures are classified as either right or left of the middle of the goal. The middle is classified as the two feet in the center of the goal occupied by the camera, tripod and camera protector. Measurement is determined with the use of drawing and measuring tools in Dartfish™.

*Lean of trunk* - refers to the kicker's upper body position in relationship to the ball at or immediately before contact. The measures are classified as either forward (i.e. head and upper body is leaning forward over the ball) or back (i.e. head and upper body is leaning back and away from the ball).

*Placement of the non-kicking foot* - refers to the kicker's left foot, (i.e. plant foot). The measure is taken of the direction of the toe on the last left footed step before impact. The measure of the plant foot is classified as left, straight or right.

#### Definition of Terms

*Anticipatory cues* - referred to as pre-impact cues, are actions in the motor skill prior to the point of contact that give predictability of the outcome.

*Dartfish™ software* - is commercial computer software used for collection, management, analysis, and presentation of observational data.

*Football* - is the sport referred to in the United States as soccer.

*FIFA* - The Federation of International Football is the world rule making body of soccer.

*Goalkeeper* - is the designated soccer position player who can use hands in their eighteen yard penalty area.

*Instep kick* - refers to a technique where the foot-ball contact point is made on the top laces of the shoe.

*Penalty kick* - results in a defensive foul occurring in the penalty box. The shot is taken by one kicker from 12 yards away with the goalkeeper in the goal (FIFA, 2009).

*Shoot-out* - is a form of penalty kicks taken to declare a winner of tied games during knock out phases of championships. Five players from each team take turns kicking penalty shots; the team with the highest tally of goals is declared the winner (FIFA, 2009).

### Assumptions

Since the selections of participants was based on the coach's top penalty kick takers on the team, it was assumed that all athletes involved in the study had an understanding of the penalty kick and the physical ability to perform the kick.

Assumptions were also made that the participants used no form of trickery while performing each kick at their optimal skill level and that all participants understood and followed the directions given by the researcher.

### Limitations

1. The collection of the anticipatory cues was done in a laboratory environment instead of game situation whereas cameras were in plain sight of the participants.

2. There was a camera in the goal where the kickers were shooting; although the camera is protected it may be a distraction.
3. There were shots that were directed down the middle of the goal which were not used as data in the study.
4. Fatigue may have become a factor in the kicker's performance.

#### Delimitations

1. All participants were right-footed male high school soccer players ranking in the top penalty kick takers on their high school soccer team.
2. The only participants who completed at least two successful kicks to each side were used in the study.
3. The researcher did not analyze any shots that were straight down the middle of the goal. The middle was the two feet occupied by the camera protector, camera and tripod. Dartfish™ software allows drawing tools to make visual criteria for shots deemed straight down the middle.
4. All data was gathered on natural grass.
5. Camera was positioned to capture the pre-impact cues from the goalkeeper's point of view.
6. Data was collected on participants' familiar practice or game field.

#### Justification

Since one goal of this study was to find evidence of pre-impact cues in the soccer penalty kick, there was practical data that can be used to start developing a video coaching tool that can teach goalkeepers to recognize and learn pre-impact cues. The video coaching tool will provide goalkeepers the chance to practice predicting penalty

kick shot direction and ultimately transfer to an increase in on-field ability to block penalty kicks. This study is also justifiable from a research aspect because it will help close some gaps in the literature by providing base line operational definitions for the pre-impact cues. Future researchers will be able to build on these findings and methods to further advance the knowledge of pre-impact cues in the soccer penalty kick.

## CHAPTER II

### REVIEW OF RELATED LITERATURE

This chapter will cover literature pertinent to the study. Topics are the Penalty kick: History, Law and Statistics; penalty kick strategies; penalty kick factors, visual search and anticipation; penalty kick anticipation; methods of collecting pre-impact cues of soccer penalty kicks; pre-impact cues in soccer penalty kicks; direct observation; Dartfish™ and summary.

#### The Penalty Kick: History, Law and Statistics

The modern game of soccer began in England in 1863, when association football (i.e. soccer) and rugby parted ways to form distinct sports for the two styles of play. The big difference was the use of hands being eliminated in soccer. The Football Association (FA) in England became the first soccer rule making body (Gerhardt, 1979). The current Governing body of soccer is the Federation Internationale de Football Association (FIFA). FIFA was formed in 1904 when representatives from France, Spain, Sweden, Switzerland, Denmark, Belgium, and Holland met to form the international law making body. England was left out of the meetings, but acknowledged the formation of FIFA. Two years later the FA and FIFA reached an agreement consolidating FIFA as the sole law making governing body of soccer (Huckel, 1996). However, FA is credited for the original rules of soccer.

In 1891, the FA introduced a rule to prevent the use of fouls to stop goal scoring opportunities. Termed the spot kick, the kick was taken 12 yards from the goal between one kicker and one goalkeeper. The first penalty kick was taken in September the same year by John Heath of the Wolverhampton Wanderers' against Accrington Stanley

(Gerhardt, 1979). No one could predict how the onset of the soccer penalty kick many years ago would today become an art, a science and ultimately a game within the game.

Law 14 in the FIFA Laws of the Games states that a penalty kick is awarded when a foul resulting in a direct free kick is committed in the eighteen yard penalty area. The ball is placed twelve yards out from the center of the goal line. The shooter is identified and the rest of the players must be outside the penalty area and at least 10 yards from the ball. The goalkeeper must stay on the line between the goal posts until the ball is struck. After the referee blows the whistle the shooter tries to one touch the ball past the goal keeper into the goal (FIFA, 2009). Law 14 was changed in 1997 to allow the keeper to move laterally along the goal line since research already showed that the keeper was doing so (Kuhn, 1988).

The penalty kick in itself is an oddity compared to the rest of soccer. Soccer is a team sport characterized by fast play and little stoppage during the course of a match. There is no other moment in a match other than a penalty kick that the game is reduced to a true one on one dual. There are two types of penalty kicks in soccer: the penalty kicks awarded in free play, and the shoot-out penalty kicks used to decide tied games in knock out phases of competitions. FIFA first introduced the shoot out to the world stage in the 1982 World Cup. The shoot-out consists of an alternating series of penalty kicks, and is won by the team that has the highest tally of goals after the five kickers have shot. If there is a tie after the five penalty kicks, the shoot-out goes to sudden death given one shot to each team until there is a winner (McGarry & Franks, 2000). One of the most characteristic features of soccer is the low scores with which matches are often decided.



Penalty kicks frequently play a decisive role, even more so since the introduction of the shoot-out (Morya, Ranvaud, & Pinheiro, 2003).

Between the World Cups in 1982 and 1998, as well as the 1996 European Championships, 69 of 81 penalty kicks taken in free play and 133 of 176 penalty kicks in the shoot-outs were successfully scored (McGarry & Franks, 2000). This data favors the kicker over the goalkeeper heavily. The statistics have not changed over the years following the 1997 rule change allowing the goalkeeper to move laterally along the goal line. Since the onset in 1982 semifinal game where Germany beat France, the World Cup final has been decided twice by a shoot-out. The 1994 World Cup in the USA introduced many American fans to soccer and the final proved to be a fantastic finish. It was the first World Cup final to be decided by penalty kicks. Brazil won the championship when Italy's Roberto Baggio sent his penalty kick sailing over the crossbar. In 2006 Italy got their chance again defeating France in a shoot-out to capture the World Cup championship (All time penalty shoot-out stats for national teams, n.d.).

#### Penalty Kick Strategies

Kuhn (1988) identified two types of strategies that kickers may take. The first is termed open loop where the whole process of kicking is pre programmed. The shooter decides without any influence regarding the keeper as to where the ball will be kicked. The main intent is power. The second type of strategy is termed closed loop where the kicker takes a reactionary role and makes the decision based on the keeper's action. This strategy is a slower kicking phase resulting in the kicker intentionally delaying their body cues in order to process the body cues and position of the keeper. There are three types of kickers: pre-determined shooters, finesse shooters and power shooters. Pre-determined

shooters tend to shoot to the same side. Finesse shooters try to get the keeper to move before the shot. Power shooters may not know where the ball is going, but hit the ball with maximum pace (Barry, 1997).

Kuhn (1988) also identified two types of strategies that keepers use. The first strategy diving movement is determined at the point of impact or immediately after. This strategy takes into account the keeper's ability to react at point of impact. The other strategy the keeper may use is to move to a side before the ball is contacted. This involves guessing or reacting to finely tuned anticipatory processes.

#### Penalty Kick Factors

Standard ball speed is about 75 kmh, a speed which means that it takes the ball only 600 milliseconds to reach the goal line from the instant it is kicked (Kuhn, 1988; Morris & Burwitz, 1989). In contrast it takes a keeper an average of 660 ms to complete a dive (Morris & Burwitz, 1989). This statistical information would seem that a keeper has no chance of saving a penalty kick based on ball speed and dive time if waiting until after the ball is struck. However, keepers do save penalty kicks even if they move after the point of impact.

The goal keeper, regardless of the statistical disadvantage, has to perform well at all levels of the game, including during penalty kicks. There are three factors that a goalkeeper must deal with when facing the penalty kick: technical, tactical and psychological. The goalkeeper must be technically fundamentally sound and able to dive at low balls. The majority of penalty kicks are shot low and to the side. The tactical areas involve recognizing the right time to dive. The third factor is psychological, meaning the keeper must be accountable for the actions (Barry, 1997). This factor also

includes the ability to recognize visual cues given by the kicker and anticipating the shot direction.

There are also different factors that affect the shooters' performance. In a study done by Jordet et al. (2007), the researcher assumed that results of penalty kicks has roots in the shooter's ability to cope with the stress, kicking form, physical fitness, and chance. There is little or no research on these factors, but with the use of game data from internet sources, Jordet was able to examine the relative importance of these factors. He looked at penalty kick stats from major competitions including the World Cup, Copa America, and European Championships between 1976 and 2004. There were a total of 409 free play penalty kicks and 41 penalty kick shoot-outs. The results showed that although skill and fatigue were important factors, the psychological aspect of coping with the stress of the importance of the kick had a stronger relationship. Jordet came to this conclusion because fewer goals were scored in the major tournament, the World Cup, than the lesser ones. Also, Jordet looked at the kickers in shoot-outs and found that kickers #4, #5, and #6-#9 scored fewer goals than kickers #1-#3. Jordet concluded that players in more stressful tournaments and players in the latter more significant shoot-out kicking positions tend to score fewer goals. One may argue these results based on other factors such as higher skilled goalkeepers are in the goal during the World Cup and simple strategy during shoot-outs. Many coaches let the best kickers go first in the shoot-out, leaving the less skilled players to shoot last resulting in more penalty kicks converted in the first part of the shoot-out.

McGarry and Franks (2000) examined strategies for winning a shoot-out in soccer. Their study is the only study that inspected the kicking order. According to

FIFA law the kickers of a penalty kick during a shoot-out must be on the field at the end of regulation play. The winner is decided when goals are tallied from the rotating five kickers of each team. One player cannot kick twice during the first five. If there is a tie then there is a sudden death phase consisting of a do or die situation between the 6<sup>th</sup>, 7<sup>th</sup>, etc. kickers on each team. This is continued until there is a penalty made and missed (FIFA, 2009). The study reports a probability analysis of the penalty shoot-out and identifies the best strategy. The best five ranked penalty kick takers on the field should be assigned to the first five shooters. They should be assigned in reverse order of effectiveness. That is the best shooter kicks last, second strongest kicks fourth, third strongest kick third, etc. If it is tied then the 6<sup>th</sup> ranked kicker is assigned the 6<sup>th</sup> position and so forth (McGarry & Franks, 2000).

These strategies reflect the findings of Jordet et al. (2007) in that the best shooters are in the most crucial kicking positions. The strategies set forth by the researcher are only practical if the coach has assigned these positions prior to the shoot-out, preferably prior to the match. Having this information before the match gives the coach the ability to tactically approach the possibility of a shoot-out during the regulation time. The coach has to use strategy to make good use of substitutions to get the best penalty kick takers and possibly the better penalty kick goalkeeper on the field before the final whistle.

### Visual Search and Anticipation

Any type of motor skill action is a result of the performer continually interacting and reacting to the surroundings. This is mostly done by visually searching the environment in which the skill is being performed. In order to perform a sport specific motor skill, the athlete must also be able to limit the focus of the visual search to the most

critical aspects of the situation (Abernethy, 1988). Visual search research focuses on identifying these critical anticipatory cues, comparing anticipatory strategies used by expert and novice athletes, the ability to teach the expert's acquired anticipatory skill to the novice, and the use of video based training to teach anticipatory skills.

Time constraints are the biggest influence when dealing with fast ball sports. The athlete must be able to visually search the situation, process the information, and then take the appropriate action. Anticipatory strategies must be acquired and developed to give the athlete the best chance to be successful. Research shows that experts have the ability to focus their visual search down to a relatively small set of pre-impact cues that gives them the ability to anticipate the outcome before the motor skill is complete (Abernethy, 1991). Abernathy's visual search and anticipation research examined racquet sports. In his research he conducts experiments that identify anticipatory cues of an overhead serve and tracks the visual search patterns of the athletes by using an eye tracking system. The use of video clips also allows him to break the film down into temporal and spatial constraints. His experiment calls for the two groups, one expert and one novice, to watch a series of filmed serves that are stopped at different times during the serve. The athletes were to predict where the serve was going to go without seeing the rest of the service action. The eye movements were also tracked to record what part of the service action each athlete was watching. The critical anticipatory cues were determined by the combination of correct anticipation and the area the athlete was visually focused on during the serve. The experts were able to predict the serve better and were able to use the anticipatory cues earlier in the service action. Abernethy

concluded that the critical anticipatory cues for the overhead serve are in the arm and racquet movement and the outward flight of the struck ball or shuttle (Abernethy, 1991).

Experts appear to differ from novices by being more reliable in prediction and are able to use earlier anticipatory cues (Abernethy, 1991). Research shows that anticipation plays a key role in experts' performance but the research is inconclusive if this can be trained. Assuming that anticipatory skills can be taught and learned, research needs to show that coaches can effectively train novices to acquire the appropriate visual search and anticipatory skills. Physically practicing the sport skill with the appropriate anticipation training is one approach (Abernethy, Wood, & Parks, 1999). The goal is to develop a training regimen without the athlete having to physically perform the task.

Research identifies three conditions that must hold true for any value to be placed on perceptual anticipation training (Stine, Arterburn, & Stern, 1982). The first condition is that training must be related to the athletes' level of competence. The second condition is that the training can be found as an alternate or supplement of the actual sport skill. The last and most important condition is the training regime should ultimately translate into improved sport performance.

Following these conditions, Abernethy (1996) assumed that researchers should use sport-specific visual training by focusing on pattern recognition and anticipation cues that experts identify to teach to novices. Abernethy also critiqued past studies and gives three limitations concerning the validity of the results. The first limitation is the lack of a placebo group resulting in uncertainty of whether the improvements were actually from the perception training intervention. Secondly, the procedures call for the athletes to respond both accurately and quickly regarding the outcome of the task. Speed and

accuracy are demanded at any level of fast ball sports but, the two may be traded off by each experimental group making it difficult to evaluate if the training is beneficial. The last limitation is the lack of evidence that the training translated to positive performance in the natural sport environment (Abernethy et al., 1999). Abernethy addressed the first two limitations in his study to examine whether the anticipatory skills of novice racquet sport players could become more expert-like by using knowledge based and video-based training. He assessed the speed and accuracy of the athletes in the pre-intervention phase and created three groups so that these aspects were constant across the groups instead of co varying between each participant. One group was then deemed the placebo group which received supervised motor skill training sessions, read books on the sport and were given videos of upper level matches to watch. The experimental group, the perceptual training group, was given supervised motor skill training and perceptual training. The perceptual training involved teaching the anticipatory skills of experts in racquet sports. The control group only undertook physical practice sessions. After the four week training period, each group was post-tested on their sport specific anticipatory skills. The experimental group, who experienced perceptual training, showed significant pre to post-training improvements in anticipatory skills. The results of the study provide obvious evidence that anticipatory skill can be trained and improved through knowledge and video based practice (Abernethy et al., 1999).

#### Penalty Kick Anticipation

The penalty kick plays a big part in determining the outcomes of many matches and championships. The odds are in the shooter's favor based on the time frame in which the goalkeeper must operate. While the likelihood of success favors the kicker, the

goalkeeper still has the ability to make saves. Franks, McGarry, and Hanvey (1999) analyzed penalty kicks in the World Cup Finals between 1982 and 1994 and showed that it takes a mere 600 milliseconds from the point of foot-ball contact for the ball to cross the goal line. However, it takes a goalkeeper between 500-700 ms to complete a dive to stop the ball. Laboratory data shows that it takes around 100 ms to react to anticipatory cues. This means that the goalkeeper must gather anticipatory cues, process the information, and initiate the dive some time before the ball is kicked (Franks, McGarry, & Hanvey, 1999).

Pre-impact cues or anticipatory cues are used to anticipate in a number of sports (Abernethy, 1988). There is very little research on the ability to use pre-impact cues in soccer. Morris and Burwitz (1989) designed a study to inspect the actions of expert goalkeepers when facing a soccer penalty kick. The goal was to examine if the goalkeepers were moving illegally and thus revealing the ability to read anticipatory cues during the approach run of the penalty taker. The study showed that the keepers moved early 96% of the time on an average of  $100 \pm 40$  ms before contact. Also, the study revealed that the goalkeepers did not seem to be guessing because the decision to dive to the appropriate side was significant. The researchers concluded that elite goalkeepers anticipated penalty kick direction using pre-impact cues (Morris & Burwitz, 1989). This study laid the groundwork for the 1997 rule change allowing goalkeepers to move laterally along the goal line during the penalty kick, and set forth a need to examine the pre-impact cues of a soccer penalty kick.

There have been a few studies since then that look at aspects of detected and acting on anticipatory pre-impact cues in a soccer penalty kick. Of these studies most



have involved examining the difference in anticipation between expert and novice goalkeepers (Morris & Burwitz, 1989; Salvendy, Williams, Van Der Kamp, & Ward, 2002), changes in anticipation between temporal stages for experienced goalkeepers (McMorris & Colenso, 1996; McMorris, Copeman, Corcoran, Saunders, & Potter, 1993; McMorris, Huxwell, & Holder, 1995), and subsequently identifying key pre-impact cues as indicators of penalty kick direction.

The objectives of the studies looking at difference in anticipation between expert and novice were to examine how playing experience affected the anticipatory performance (Salvendy et al., 2002; Williams & Burwitz, 1993). The overall results concluded that expert goalkeepers can use pre-impact cues to anticipate ball direction more effectively than their novice counterparts. Also, this ability can be taught using video based training; therefore anticipation training is supported as a penalty saving strategy.

Temporal occlusion research has been an area of documentation in penalty kick anticipation. The studies used video collected from the goalkeeper point of view that was edited to stop at points during the penalty kick approach. The research shows that different occlusion points offered different predictability values. McMorris and Colenso (1996) addressed few major time limitations in their study by omitting the two frames after contact occlusion point and replacing it with a one frame before contact point. According to Kuhn (1988), the keeper must initiate his diving motion at or right before the point of contact allowing enough time for a save. The other occlusion points were two frames before contact and at contact. The results showed that the experts could use all occlusion points, but the most significant ones occurred later in the approach run.

### Methods of Collecting Pre-Impact Cues of Soccer Penalty Kicks

Anticipatory cue utilization has been found to be helpful in many sports activities including the penalty kick in soccer (Abernethy, 1988; Williams & Burwitz, 1993). Collection of the anticipatory pre-impact cues in the soccer penalty kick relied on one or a combination of three different methods: of self-reporting cues, recording player's visual search strategies, and filmed tasks edited with occlusion points. The following reported the cues from different studies and the methods of collection, and a critical look of the collection methods.

Studies used post-hoc interviews or questionnaires to gather anticipatory cues from the athletes (McMorris et al., 1993; McMorris et al., 1995; Williams & Burwitz, 1993). As a single method of collecting cue information, self-reporting may contaminate results based on the players' own biases and expectations (Abernethy, 1991). Another way to collect visual anticipatory cues is recording the player's visual search patterns. This can be done with an eye tracking system. Kim and Lee's (2006) study used an eye movement tracking system to track the gaze patterns of soccer goalkeepers in successful defense of penalty kicks. The use of eye tracking systems is the most technically advanced form of cue collection, but this method is not without its downfalls. Eye movement recordings were related to the athlete's line-of-sight and only revealed general information. Peripheral vision is used to pick up cues in every sport especially when the target is on the move. Also, eye tracking systems only measures the line of sight not what the athletes are seeing (Abernethy, 1991). The other way to identify pre-impact cues was with the use of video footage. Researchers using edited film of penalty kicks determined what occlusion points seemed to be more effective, however the results were

in relationship to time and the post hoc-interviews that revealed the pre-impact cues were never checked for accuracy in the videos (McMorris et al., 1993; McMorris & Colenso, 1996; McMorris et al., 1995;).

### Pre-Impact Cues in Soccer Penalty Kicks

Williams and Burwitz (1993) reported the information pertaining to the anticipation of side resulted in watching the approach to the ball (Williams & Griffiths, 2002), the angle of kicking foot and alignment of the hips prior to ball contact. The hip position was defined as the most important cue; regarding the side of the goal the ball was shot. Open hips meant the ball was going to the kicker's right and square hips meant the ball was traveling to the kicker's left side. McMorris et al. (1993) and McMorris et al. (1995), reported through post hoc-interviews that the keepers used point of foot-ball contact, angle of kicker's trunk, and position of the approach run as pre-impact cues. Kim and Lee's (2006) eye movement tracking study showed that the elite goalkeepers fixed their gaze on shoulder zone, kicking leg, and between the ball and the non-kicking leg during the approach run to be the most effective cues in anticipating penalty kick direction.

Franks, McGarry, and Hanvey (1999) used video footage of penalties taken during the 1996 European Championships to examine the following visual cues; starting position, angle of approach run, the lean of the trunk, the placement of the non-kicking foot prior to contact, and the point of contact on the ball of the kicking foot. The anticipatory cue that had an 85% predictability rate was the placement of the non-kicking foot (Franks, McGarry, & Hanvey, 1999 ).

Personal experience revealed that the non-kicking side arm also is a pertinent pre-impact cue. Kinetic research shows that expert soccer players performing the common instep kick execute a fast arm flexion and adduction on the non-kick side (Shan & Westerhoff, 2005). This tendency or lack thereof is hypothesized to predict the direction of the shot.

An important thing to consider is the time frame of the cues. Cues gathered too early in the approach may lead to the goalkeeper giving away the diving side and giving the kicker cues to direct the shot accordingly. Cues gathered too late may not give the keeper enough reaction time.

#### Direct Observation

Direct observation is a noteworthy tool in the assessment of physical activities because it provides practical data from the setting in which the activity occurs (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Chow, McKenzie, & Louie, 2008). Black (1999) states that observational research has practical implications whereas other methods may be inadequate. McKenzie (2002) identifies key elements of systematic observation in assessing physical activity: instrumentation, procedures, and measurement properties.

#### *Instrumentation*

Systematic or direct observation methods are used to generate data. The instrumentation or system to be used must be designed specifically for the purpose of the study and include operational definitions of each category to be observed, protocol for instrument use, and parameters for coding the data. Most systems are designed to measure observed frequencies, length of time, and latency; however there are many

observational techniques that can be used to collect data. Computer systems are available for use in collecting, managing, analyzing and presenting observational data. With the use of videotape or media files, researchers can transfer data directly to the computer system.

### *Procedures*

Collecting accurate data with direct observation requires an acute attention to detail. The researcher must be familiar with each category that is to be observed and have training on how the categories were coded. The researcher must also know when and where to watch for the categories during the observational period. The number of categories to be coded must be appropriate to ensure the observer has the ability to stay focused and actually observe them. Using videotapes for data collection provides permanent samples that can be viewed repeatedly in an environment away from distractions. Videos are useful when the observation site is fixed and there are a small number of participants. The disadvantages of using videotapes are cost (i.e. equipment) and the time needed not only to analyze the data but to set up the equipment at the observation site.

### *Measurement Properties*

Direct observation research provides data from an actual setting and is useful to researchers and practitioners; however, the data is only useful if the instrumentation is both valid and reliable. Systematic observation is a direct measure of behavior and as long as the categorical operational definitions used to code are adhered to, there is little room for interpretation. The lack of assumptions leads to a high internal validity. Reliability in observational research refers to the consistency of coding among trained

researchers. Inter-rater reliability can be achieved by comparing percentages of coding agreement between two observers viewing the same participants and occasion.

Reliability can also be assessed by comparing results of when the same person codes the same video twice (i.e. intra-observer reliability).

### Dartfish™

In 1997, after extensive research in image and video processing. SimulCam™ technology was created and developed at the Swiss Federal Institute of Technology in Lausanne, Switzerland. Subsequent to enthusiastic response from TV producers and sports viewers alike, five international business and IT specialists founded Dartfish™ (then known as InMotion Technologies Ltd.) in December 1998 to commercially develop SimulCam™ and other digital imaging applications. The small start-up quickly grew and became well known for its innovative digital image enhancements in the sports broadcast world. SimulCam™ technology was followed by StroMotion™, which was launched in January 2001. Based on its technological know-how, Dartfish™ soon branched out into other growth areas such as interactive internet content enhancement and the development of cutting edge sport training applications. Today, our technologies and know-how are widely recognized for exclusive televised broadcast footage and breakthrough training applications for sports, education, healthcare and more ([www.dartfish.com](http://www.dartfish.com), n.d.).

### Summary

Penalty kicks play a vital role in the modern game of soccer. The low scoring nature of soccer matches emphasize the importance of every aspect of the game. The outcomes of many games and championships are decided by penalty kicks in free play and shoot-outs. Goalkeepers are at a disadvantage in being successful based on the time

frame in which they operate in a penalty kick. It is vital that pre-impact cues are used to help give the goalkeeper every advantage when facing a penalty kick. The pre-impact cues are starting position and angle of approach run, angle and position of the kicking foot at impact, alignment of the hips before impact, angle and lean of body trunk, shoulder zone and action of non-kicking side arm, and non-kicking leg and plant foot. The methods used to identify these pre-impact cues challenges the validity of their scientific value, however direct observation as a procedure is a valid alternative that will generate scientific data.

### CHAPTER III

#### METHODOLOGY

The procedures and techniques used in this study are discussed and described in this chapter. The procedures include participants, instrumentation, procedures, pilot study, and data analysis.

##### Participants

Permission was obtained from The University of Southern Mississippi's Human Participants Review Committee to conduct the study. Participating area high school administration was contacted and written permission was obtained to conduct the study on the school site. Fifty right-footed male high school soccer players were selected from area high school soccer teams. The researcher requested that the team's coach identified the top right-footed kickers that they would feel comfortable using during a penalty kick or shoot-out. The participants were used if during the course of the data collection they were able to successfully complete two kicks to each side of the goal. All but one participant was able to meet this criterion, resulting in using a total of 49 players. All participants and guardians were required to complete an informed consent form and were asked to complete a video permission form.

##### Instrumentation

Dartfish™ Team Pro version computer video software was used to analyze, manage and present the pre-impact cues. Dartfish™ with the use of digital video cameras allowed the researcher to download the video via firewire directly to the computer. This capability reduced the chances of losing data, and gave the researcher the best possible video quality. Dartfish™ has tools to enhance video clips with the use of different



modules. The Dartfish™ tagging module was primarily used in this study. Tagging is a way to mark video clips and create searchable index of events and information related to the events. Dartfish™ tagging is very useful in breaking down game film; however the software also allowed the researcher to create a customized tagging panel to fit the needs of the project.

The researcher created a customized tagging panel to identify and code the presence of pre-impact cues of the soccer penalty kick (see Appendix B). The first task was to import clips into the tagging panel, this was done directly from the camera or imported through the library. Each video clip was coded for pre-impact cues and direction of shot. The specific pre-impact cues measured were the position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. Using the operational definitions the researcher coded the pre-impact cues of the soccer penalty kick by clicking the appropriate tagging buttons. Dartfish™ has the capability to pause, play and rewind the clip; also the researcher can analyze the clip frame by frame. With the use of operational definitions, there was little room for interpretation leading to high instrumentation validity. A pilot study was run to ensure that the hypothesized pre-impact cues were present. Reliability of the instrument was tested in the pilot study, by checking the consistency of inter-rater reliability.

### Procedures

The following equipment was used in this study: two digital video cameras mounted on tripods (tripods stood at least 70 inches tall), a computer with a version of Dartfish™ software having drawing tools and tagging capabilities, a firewire to transfer

data from the digital video camera to the computer, research sites with a standard size goal outfitted with net and appropriate penalty kick marks, proper age appropriate (size five) soccer balls, and protection for goal line tripod and camera (see Appendix D).

The players went through a warm-up to make sure there were no injuries. The warm-up concluded with a few minutes of penalty shots on goal with the tripod in position to get the players used to the location of the camera. Camera One was set up just behind the goal line on a tripod at a height of 70 inches. Previous research shows that this camera position provided a viewpoint of a six foot tall keeper in a slightly crouched position (McMorris et al., 1993). Camera Two was set at the same height on the top of the penalty arc, ten yards behind the penalty mark. This camera angle ensured accurate records of shot direction. After the warm-up the researcher placed Camera One on the tripod.

The researcher checked on the equipment and turned the cameras to the on position. The kicker was identified and the data collection process began. At this point the kicker was informed of what was required of him. The researcher revealed some implicit details stating that the data collected will be used to calculate speed and accuracy. This helped replicate game-like intensity resulting in more reliable data. The cameras were now recording every kick. The researcher had the soccer balls so the kicker received the instructions each time he was given a ball. The researcher followed one of two predetermined set of shot orders for each kicker to ensure that the data reflects shots directed to each side of the goal. There were two shot orders to keep the other kickers from learning the pattern. The first three kicks taken were practice to make sure the instructions were clearly understood. The last eight were the data shots. Each shot

order had equal numbers of shot directions, but multiple shot orders helped reduce inter-rater bias while coding:

Shot order 1.

- R-L-Y(practice) R-L-Y-R-R-L-Y-L

Shot order 2.

- L-R-Y(practice) R-R-L-L-Y-R-L-Y

Shot direction key:

R- Shot directed to the kickers right.

L- Shot directed to the kickers left

Y- Shot directed by the choice of kickers

Each shot sequence was as followed:

1. Kicker received the ball and direction of the shot from the researcher
2. Kicker placed the ball on the penalty mark and took kick
3. Ball was retrieved from goal

These steps were completed until all eleven shots were taken. As a precaution, the researcher had an equipment protector built that was anchored into the ground. The protector was a welded metal player-shaped piece that was placed on the goal line, in front of the camera and tripod. The primary purpose was to protect the equipment from a ball struck down the middle. This did not affect the study because shots down the middle were excluded from the data and the player shape mimicked the appearance of a goalkeeper. The data collection continued with the next kicker following the same

protocol until all kickers' data had been collected. Each school collection site followed the same protocol.

Dartfish™ Team Pro version was used in this study. After the raw video had been collected on the digital video cameras (Canon Digital Video Camcorder NTSC Optura 10), the import function allowed the researcher to upload content to the computer via a fire wire connection. This capability reduced chances of losing data, and gave the researcher the best possible video quality. Dartfish™ Team Pro allowed the researcher to archive the video and any analysis. There are many different analysis functions in Dartfish™ Team Pro, but this study used video replay, drawing tools and tagging panels. Video replay allowed the video clip to be watched in varying speed or a frame at a time without losing video quality. Drawing tools were also used to give the researcher a criterion for coding missed shots. Tagging is a way to mark video clips and create searchable index of events and information related to the events. Dartfish™ tagging is very useful in breaking down game film; however the software allowed the researcher to create a customized tagging panel that fit the needs of this project. The researcher created a customized tagging panel to identify and code the presence of pre-impact cues of the soccer penalty kick.

### Data Analysis

Data variables collected from the participants were coded and analyzed using the created tagging module in the Dartfish™ software (see Table 1). SPSS™ software was used to analyze the coded data to report significance in relationship to the null hypotheses. Logistical regression statistics tested the significance of the independent

variables of HO1. A Chi-squared goodness of fit test reported at a .05 significance level for HO2-HO6 (see Table 2).

Table 1

*Dependent and Independent Variables*

Sample	Dependent variable	Independent variables
Male right-footed high school age soccer players	Direction of penalty kick	Position of the approach run Alignment of the hips Lean of body trunk Placement of non-kicking foot Action of non-kicking side arm

Table 2

*Null Hypotheses and Methods of Data Analysis*

Null Hypotheses	Methods of Data Analysis
HO1: There are no significant pre-impact cues that determine shot direction of the soccer penalty kick.	Logistic regression analysis
HO2: Position of the approach run will not determine shot direction of the soccer penalty kick.	Chi-square
HO3: Alignment of the hips will not determine shot direction of the soccer penalty kick.	Chi-square
HO4: Trunk lean of the body will not determine shot direction of the soccer penalty kick.	Chi-square
HO5: Placement of the non-kicking foot will not determine shot direction of the soccer penalty kick	Chi-square
HO6: Action of the non-kicking side arm will not determine shot direction of the soccer penalty kick.	Chi-square

### Pilot Study

A pilot study was conducted to verify that the researcher could correctly implement the proposed procedures and to reliably classify the pre-impact cues. The participants were two male right-footed high school soccer players from the same team. The coach was asked to provide the top two right-footed penalty takers on the team. It was apparent that one of the players was not highly skilled in taking penalty kicks. One of the assumptions of the study was that the coach provided adequate skilled penalty kick takers. The researcher reiterated this point to make sure the validity is not thrown off by less skilled players. The shot order was the same for each kicker: R-L-Y (practice) R-L-Y-R-R-L-Y-L.

The pilot study data collection revealed that procedural protocol was satisfactory. The participants understood the directions, the cameras worked properly and positions of the cameras allowed for collection of the needed data. However, the researcher needs to have a tape measure to ensure the appropriate distance for the penalty kick (i.e. 12 yards) and a tool to mark the correct position in case the site is not properly marked. Shots that were directed down the middle posed significant threat to breaking the camera, the researcher needs to provide an equipment protector.

The second goal of the pilot study data was to check the researcher's ability to use the Dartfish™ software and to examine the prevalence of the hypothesized pre-impact cues. The researcher found that the hypothesized pre-impact cues were present in the data and the tagging panel created by the researcher worked well to code the pre-impact cues.

The third goal was to examine the reliability in classifying the pre-impact cues. The instrumentation was tested by teaching another rater to code the data. The researcher provided operational definitions and demonstrated how the tagging panel worked. This took about thirty minutes. The rater then coded the data from the pilot study independently (see Appendix C). Below are the inter-rater reliability percentages by pre-impact cues (see Table 3).

Table 3

*Inter-Rater Reliability Percentages*

Cues	Position of the approach run	Trunk Lean	Alignment of the hips	Direction of Non-kicking foot	Action of non-kicking side arm
Inter-rater reliability percentage	62.5%	50%	87.5%	81%	100%

The results of the inter-rater reliability showed that the trunk lean cue was the least consistently coded. This is an important cue in the literature but was very hard to determine from this camera position. A camera view from the side of the kicker would be the most reliable angle to determine trunk lean, but the most practical view is from the goal line camera. The position of the approach run had a low inter-rater percentage; however the researcher modified the operational definition to give a more consistent meaning of direct and wide. Direction of the non-kicking side foot was coded with measure of left and right, after discussing the operation definition with the expert the researcher added a third position of straight. Inter-rater reliability test pointed out the inconsistency of the trunk lean, but also led to strengthening the operational definitions of the other cues.

The last result of analyzing the pilot study data revealed the tendency to have intra-rater bias. The researcher found that knowing the direction of the shot before hand, could influence the tendency to code based on shot direction rather than following the operational definitions. Also, becoming familiar with the difference within a single players action could threaten validity. The researcher addressed these problems by editing the video to the point of impact so that shot direction is unknown while coding.



## APPENDIX A

## IRB APPROVAL FORM



## THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

118 College Drive #5147  
 Hattiesburg, MS 39406-0001  
 Tel: 601.266.6820  
 Fax: 601.266.5509  
 www.usm.edu/irb

**HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE  
 NOTICE OF COMMITTEE ACTION**

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months.  
 Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **C28072101**

PROJECT TITLE: **Soccer Penalty Kick Pre-Impact Cues of Male Right-Footed High School Age Soccer Players**

PROPOSED PROJECT DATES: **09/18/09 to 09/17/10**

PROJECT TYPE: **Change to a Previously Approved Project**

PRINCIPAL INVESTIGATORS: **Jason Ryan Jones**

COLLEGE/DIVISION: **College of Health**

DEPARTMENT: **Human Performance & Recreation**

FUNDING AGENCY: **N/A**

HSPRC COMMITTEE ACTION: **Expedited Review Approval**

PERIOD OF APPROVAL: **10/12/09 to 10/11/10**

*Lawrence A. Hosman*  
 Lawrence A. Hosman, Ph.D.  
 HSPRC Chair

*10-13-09*  
 Date

## APPENDIX B

### CUSTOMIZED TAGGING PANEL

pk tagging panel - Tagging Editor

File Help

Panel Editor Database Editor

ToolBox

Event Buttons

Event Continuous Event

Value Buttons

Value Persistent Value

Text Box Score Panel

Layout Containers

Group Box Tab Group Box

Team Management

Team Manager Team Group Box

Hint: Drag and drop items from the Toolbox to the Tagging Panel

PENALTY KICK PRE IMPACT CUES

Click to add page

PENALTY KICK

OS Brandon Pearl Madison Florence HC Gulfport

PENALTY KICK

1 2 3 4 5 6 7 8 9 10 11

PLAYER

1 2 3 4 5 6 7

PLANT FOOT OFF ARM

ANGLE OF HIPS ANGLE OF APPROACH TRUNK LEAN TOE DIRECTION ACTION Direction pre shot Result

Click to add page

OPEN

CLOSED

Group Box Properties

Appearance	GroupBox1
Item Id	
Label	PENALTY KICK
Event	
Category	

Layout containers are used to organise other items on the tagging panel.

## APPENDIX C

## RAW DATA OF PILOT STUDY

PLAYER	SHOT	SHOT DIRECTION	ANGLE OF APPROACH	TRUNK LEAN	ANGLE OF HIPS	PLANT FOOT	ARM	RATER
1	1	RIGHT	DIRECT	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	2	LEFT	WIDE	FORWARD	CLOSED	LEFT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	3	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	2
	4	LEFT	DIRECT	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	2
	5	RIGHT	DIRECT	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	6	RIGHT	DIRECT	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	7	RIGHT	DIRECT	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	8	RIGHT	WIDE	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
2	9	LEFT	DIRECT	FORWARD	CLOSED	LEFT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	10	LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	11	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	OPEN	LEFT	EXTENSION	2
	12	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	OPEN	LEFT	EXTENSION	2
	13	RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	2
	14	RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	2
	15	RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	16	RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
			62.50%	50%	87.50%	81%	100%	

## APPENDIX D

## CAMERA PROTECTOR



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CHAPTER IV

MANUSCRIPT ONE:

SOCCER PENALTY KICK PRE-IMPACT CUES OF MALE RIGHT-FOOTED HIGH  
SCHOOL SOCCER PLAYERS

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**Key words:**

Direct Observation, Penalty Kick, Dartfish™, Pre-Impact Cues

### **Abstract**

The purpose of this study was to use direct observation methods to collect evidence of pre-impact cues in a soccer penalty kick and to analyze their predictive powers in determining shot direction. The five pre-impact cues were position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. Video was collected and then analyzed using a Dartfish™ tagging panel. There were a total of fifty male high school right-footed participants. Coaches from area high school soccer teams provided their top penalty kick takers to participate in the study. Video was collected on the team's practice/game site from two vantage points; from the goal line and behind the penalty arch. Logistic regression analysis revealed evidence that the pre-impact cues were effective in predicting shot direction, with the alignment of the hips and the trunk lean significant indicators of shot direction ( $p < .001$ ). Further chi-square analyses of the individual pre-impact cues revealed each was a significant shot direction indicator ( $p < .001$ ).

## **Introduction**

According to soccer's governing and rule making body, the Federation of International Football Association (FIFA), the penalty kick rule was established in 1891 to contest the growing use of illegal acts to prevent goals from being scored, particularly by handling the ball (Gerhardt, 1979). As FIFA Law 14 currently stands, during a penalty kick the goalkeeper must be on the goal line, facing the kicker, between the posts until the ball is kicked from a distance of 12 yards. The keeper has the ability to move laterally, but must not encroach forward off the line until the ball is struck. The shooter is identified and all players must be at least ten yards from and behind the ball (FIFA, 2009).

FIFA introduced the penalty kick shoot-out to decide tied matches in the 1982 World Cup. The tie-breaker or penalty kick shoot-out consists of an alternating series of penalty kicks, and is won by the team that has the highest tally of goals after the five kickers have shot. If there is a tie after the five penalty kicks, the shoot-out goes to sudden death given one shot to each team until there is a winner (McGarry & Franks, 2000). Since then, many competitions and games have been decided this way, such as National Collegiate Athletic Association (NCAA) championships, Major League Soccer (MLS) championships and World Cup Finals. There have been 41 penalty shootouts and 409 penalty kicks taken in the World Cup, European Championships, and Copa America Games between 1976 and 2004 (Jordet, Hartman, Visscher, & Lemmink, 2007).

Goalkeepers are at a significant disadvantage when it comes to the probability of successfully saving a penalty kick. Penalty kicks records from World Cup competitions reveal that a goal is scored at a rate of around 80% (DiCicco, n.d). However, penalty

kicks are successfully blocked by goalkeepers. To be successful, goalkeepers must gather anticipatory pre-impact cues, process the information, and initiate the dive some time before the ball is kicked (Franks, McGarry, & Hanvey, 1999; Kuhn, 1988). Anticipatory cue utilization has been found to be helpful in many sports activities including the penalty kick in soccer (Abernethy, 1988; Williams & Burwitz, 1993).

There is very little research on the ability to use pre-impact cues in soccer. Morris and Burwitz (1989) designed a study to inspect the actions of expert goalkeepers when facing a soccer penalty kick. The goal was to examine if the goalkeepers were moving illegally and thus revealing the ability to read anticipatory cues during the approach run of the penalty taker. The study showed that the keepers moved early 96% of the time on an average of  $100 \pm 40$ ms before contact. Also, the study revealed that the goalkeepers did not seem to be guessing as to which side they dove because the decision to dive to the appropriate side was significantly correct ( $p < .01$ ). The researchers concluded that elite goalkeepers successfully anticipated penalty kick direction using pre-impact cues. This study laid the groundwork for the 1997 rule change allowing goalkeepers to move laterally along the goal line during the penalty kick, and set forth a need to examine the pre-impact cues of a soccer penalty kick.

There are a few researchers who have examined the role of anticipatory pre-impact values in the soccer penalty kick. Of these studies most have involved examining the difference in anticipation between expert and novice goalkeepers (Morris & Burwitz, 1989; Salvendy, Williams, Van Der Kamp, & Ward, 2002), changes in anticipation between temporal stages for experienced goalkeepers (McMorris & Colenso, 1996; McMorris, Copeman, Corcoran, Saunders, & Potter, 1993; McMorris, Hauxwell, &

Holder, 1995), and subsequently identifying key pre-impact cues as indicators of penalty kick direction.

The existing research on pre-impact cues in the soccer penalty kick presented six common variables: starting position and position of the approach run (Franks, McGarry, & Hanvey, 1999; McMorris, Copeman, Corcoran, Saunders, & Potter, 1993; McMorris et al., 1995; Williams & Burwitz, 1993; Williams & Griffiths, 2002), angle and position of the kicking foot at impact (Kim & Lee, 2006; McMorris et al., 1993; McMorris & Hauxwell, 1995; & Williams & Burwitz, 1993), angle of the hips before impact (Williams & Burwitz, 1993), angle and lean of the upper body trunk, (Franks et al., 1999; McMorris et al., 1993; McMorris & Hauxwell, 1995), shoulder zone (Kim & Lee, 2006), and non-kicking leg and plant foot (Franks et al., 1999; Kim & Lee, 2006).

Researchers collected the pre-impact cues by using one or a combination of the following: self-reporting questionnaires, visual search patterns, or video edited to different occlusion points. Studies using post-hoc interviews or questionnaires to gather anticipatory cues from the athletes (McMorris et al., 1993; McMorris et al., 1995; Williams & Burwitz, 1993) as a single method of collecting cue information, may contaminate results based on the players' own biases and expectations (Abernethy, 1991). Kim and Lee's (2006) use of an eye movement tracking system to track the gaze patterns of soccer goalkeepers in successful defense of penalty kicks only relates to the athlete's line-of-sight and revealed general information not specifically what the athletes were seeing (Abernethy, 1991). Research using edited film of penalty kicks determined what occlusion points seemed to be more effective in predicting direction of the penalty kick; however, the occlusion points were related to time frames and the cues were self-reported

(Franks et al., 1999; McMorris et al., 1993; McMorris et al., 1995; McMorris & Colenso, 1996). Although these studies reported valuable information about pre-impact cues in the soccer penalty kick, the methods used to identify these pre-impact cues provided little quantifiable scientific evidence. In order to generate scientific data of pre-impact cues of a soccer penalty kick, the existing common variables were combined to form five distinct pre-impact cues; position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. These five cues could be observed from the goalkeeper's point of view, which allowed the researcher to use direct observation methods to collect and analyze pre-impact cues of a soccer penalty kick.

Direct (systematic) observation has been used in the study of human behavior in natural settings, including physical activity (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Chow, McKenzie, & Louie, 2008). The fundamental purpose of direct observation is to classify activities into separate categories that can be quantified and analyzed in greater detail. There have been technological advances that allow observational codes to be entered, analyzed, and stored by computers. With the use of digital video cameras, the researcher can obtain observational data and later transfer it to a computer making this methodology very useful and appealing (McKenzie, 2002). Observational studies provide an alternative to a lack of any scientific evidence, providing the researcher acknowledges the associated limitations (Black, 1999). Direct observation of pre-impact cues in soccer penalty kicks is a way to generate data where previous studies only reported information.

## **Methods**

### **Participants**

Permission was obtained from The University of Southern Mississippi's Human Participants Review Committee to conduct the study. Participating Mississippi high school administration was contacted and written permission was obtained to conduct the study on the school grounds. The high school setting offered the researcher an educational structured environment. Fifty right-footed male high school soccer players (ages 14-18) were selected from seven area high school soccer teams. The team's coach selected the top seven or eight right-footed kickers that were competent to represent the team during an actual penalty kick or shoot-out and provided them each with the supplied permission forms. The participants were used if during the course of the data collection they were able to successfully complete two kicks to each side of the goal. All but one participant was able to meet this criterion, resulting in using a total of 49 players. All participants and guardians were required to complete an informed consent form and asked to complete a video permission form.

### **Apparatus**

Dartfish™ Team Pro version computer video software was used to analyze, manage and present the pre-impact cues. Dartfish™ with the use of digital video cameras (Canon Digital Video Camcorder NTSC Optura 10) allowed the researcher to download the video via firewire directly to the computer. This capability reduced the chances of losing data, and gave the researcher the best possible video quality. Dartfish™ has tools to enhance video clips with the use of different modules. The tagging module was primarily used in this study. Tagging is a way to mark video clips and create a searchable

index of events and information related to the events. Dartfish™ tagging is very useful in breaking down game film; however, the software allows the researcher to create a customized tagging panel to fit the needs of the project.

The primary researcher created a customized tagging panel to identify and code the presence of pre-impact cues of the soccer penalty kick. The specific pre-impact measured were the position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. The following operational definitions are used to code the pre-impact cues.

**Operational definitions.**

1. Action of non-kicking side arm: Action on the non-kicking side arm refers to the position of the kicker's left arm. The measures were taken during the final stages of the approach run coinciding with the last plant foot step. The measures will be classified as either up (i.e. quick and deliberate left arm movement extended to the side and hand raised above the waist) or down (i.e. arm stays close to the body and hand remains lower than the waist).
2. Position of the approach run: Position of the approach run refers to the kicker's position relative to the ball at the point when the kicker begins to move towards the ball. The measures were classified as either direct (i.e. within three steps to the left of the ball) or wide (i.e. greater than three steps to the left of the ball).
3. Alignment of the hips: Alignment of the hips refers to the alignment of the kicker's hips starting just before ball contact and finishing at ball contact. The measures were classified as either open (i.e. hip alignment is not becoming



parallel with the goal line) or closed (i.e. hip alignment is or is becoming parallel to goal line).

4. Lean of trunk: The lean of trunk refers to the kicker's upper body position in relationship to the ball at or immediately before contact. The measures were classified as either forward (i.e. head and upper body were leaning forward over the ball) or back (i.e. head and upper body were leaning back and away from the ball).
5. Placement of non-kicking foot: Placement of the non-kicking foot refers to the kicker's left foot, (i.e. plant foot). The measure was taken of the direction of the toe on the last left footed step before impact. The measure of the plant foot was classified as left, straight or right.

## **Procedures**

The researcher met with the participants and the coach before practice on the collection days. Before the data collection began, the permission forms were collected and the researcher set up the camera equipment and had the moved goal if necessary. If the sun was a factor, the goal was placed so that the goal line camera was facing opposite of the sun. The correct distance was marked off and penalty mark was spray painted on the field. The researcher chose days that the field was in dry conditions so the kicking area would stay as pristine as possible as not to affect the placing of the ball. The total time varied by school depending on the prep-time and actual recording time, but the researcher allowed 30 minutes to set up and one hour to observe the penalty kicks.

To begin the collection process, the participants went through a warm-up to make sure there were no injuries. The warm- up concluded with a few minutes of penalty

shots on goal with the tripod and camera protector in position to get the players accustomed to the location of the cameras. Camera One was set up just behind the goal line on a tripod at a height of 70 inches. Previous research showed that this camera position provided a viewpoint of a six foot tall goalkeeper in a slightly crouched position (McMorris et al., 1993). Camera Two was set at the same height on the top of the penalty arc, ten yards behind the penalty mark. This camera position ensured accurate records of shot direction. After warm-up the researcher placed Camera One on the tripod.

The researcher checked on the equipment and turned the cameras to the on position. The kicker was identified and the data collection process began. At this point the kicker was informed of what was required of him. The researcher revealed some implicit details stating that the data collected was used to calculate speed and accuracy. This helped replicate game-like intensity resulting in more reliable data. The cameras were now recording every kick. The researcher held the soccer balls so the kicker received the instructions each time he was given a ball. The researcher followed one of two predetermined set of shot orders for each kicker to ensure that the data reflects shots directed to each side of the goal. There were two shot orders to keep the other kickers from learning the pattern. The first three kicks taken were practice to make sure the instructions were clearly understood. The last eight were the data shots. Each shot order had equal numbers of left and right shot directions plus two kickers' choice direction. Multiple shot orders helped reduce inter-rater bias while coding, and having a kickers' choice direction ensured that the participant was able to kick to a preferred side.

Each shot sequence followed the same protocol.

1. Kicker received the ball and direction of the shot from the researcher.
2. Kicker placed the ball on the penalty mark and took the kick.
3. Ball was retrieved from goal.

These steps were completed until all eleven shot were taken. As a precaution, the researcher had an equipment protector built that was anchored into the ground. The protector was a welded metal player-shaped piece that was placed on the goal line, in front of the camera and tripod. The primary purpose was to protect the equipment from a ball struck down the middle of the goal and relieved anxiety from the participants. This did not affect the study because shots down the middle were excluded from the data and the player shape mimicked the appearance of a goal keeper. The collection procedure continued with the next kicker following the same protocol until all kickers' completed the penalty kick shots. The researcher mixed up the predetermined shot order as needed. Each site collection followed the same protocol.

After collecting the data, the researcher transferred the videos to the computer using a firewire connection. Dartfish™ video computer software was used to analyze the video. Only the subjects who were able to complete two successful penalty kick shots to each side were retained in the study. This ensured consistency in participant performance. Dartfish™ tagging module provided the capability to code the data from each of the shots. Also, the researcher used drawing tools within the program to create criteria to further analyze the direction of the shot.

## Results

The principal results support the anticipatory value of the pre-impact cues in indicating soccer penalty shot direction. The pre-impact cues can significantly predict shot direction in the soccer penalty kick, Chi-square ( $N=337$ ,  $df=6$ ) = 349.83,  $p<.001$ , Naglkerke R-square = .865. There is a 93.8 % correct overall prediction rate when using the five pre-impact cues to indicate shot direction (see Table 1). Logistic regression analysis showed that the alignment of the hips and the trunk lean were significant ( $p<.001$ ) indicators of shot direction (see Table 2).

Table 1

### *Percentage of Correct Shot Direction Prediction*

			Predicted		Percentage Correct
			Direction		
			1 right	2 left	
Observed	Direction	1 right	141	9	94.0
		2 left	12	175	93.6
	Overall Percentage				93.8

Table 2

### *Variables in the Logistic Regression Equation*

	B	S.E.	Wald	df	Sig.	Exp(B)
Position of approach run	-.435	.566	.590	1	.442	.647
Alignment of the hips	-3.732	.646	33.328	1	.000	.024
Trunk Lean	2.178	.543	16.111	1	.000	8.831
Foot			2.937	2	.230	

Table 2 (continued).

Foot(1)	-18.509	5042.174	.000	1	.997	.000
Foot(2)	1.368	.798	2.937	1	.087	3.926
Arm	-.147	.677	.047	1	.828	.863
Constant	1.006	.837	1.620	1	.203	2.903

### Alignment of the Hips

The alignment of the hips is a significant predictor of shot direction, Chi-square ( $N=337$ ,  $df=1$ ) = 261.51,  $p<.001$ . Table 3 shows the predictive percentages of the alignment of the hips and shot direction. Closed hips show a stronger prediction that the shot will go to the goalkeeper's right. Open hips show a stronger prediction that the shot will go to the goalkeeper's left.

Table 3

### *Alignment of the Hips by Direction*

			Direction		Total
			Right	Left	
Alignment of the Hips	Closed	Count	143	13	156
		% within Direction	95.3%	7.0%	46.3%
	Open	Count	7	174	181
		% within Direction	4.7%	93.0%	53.7%
Total	Count		150	187	337
	% within Direction		100.0%	100.0%	100.0%

### Trunk Lean

The direction of the trunk lean is a significant predictor of shot direction, Chi-square ( $N=337$ ,  $df=1$ ) = 144.21,  $p<.001$ . Table 4 shows the predictive percentages of the trunk lean and shot direction. The backward trunk lean shows a stronger prediction that

the shot will go the goalkeeper's left. A forward trunk lean shows a stronger prediction that the shot will go to the goalkeeper's right.

Table 4

*Trunk Lean by Direction*

			Direction		Total
			Right	Left	
Trunk Lean	Back	Count	25	154	179
		% within Direction	16.7%	82.4%	53.1%
	Forward	Count	125	33	158
		% within Direction	83.3%	17.6%	46.9%
Total			Count	150	187
			% within Direction	100.0%	100.0%

**Position of the Approach Run**

The position of approach run is a significant predictor of shot direction, Chi-square ( $N=337$ ,  $df=1$ ) = 36.04,  $p < .001$ . Table 5 shows the predictive percentage of the position of the approach run and shot direction. A direct approach position shows a stronger prediction that the shot will go the goalkeeper's right. A wide approach position shows a stronger prediction that the shot will go to the goalkeeper's left.

Table 5

*Position of the Approach Run by Direction*

			Direction		Total
			Right	Left	
Position of the Approach Run	Direct	Count	113	80	193
		% within Direction	75.3%	42.8%	57.3%
	Wide	Count	37	107	144
		% within Direction	24.7%	57.2%	42.7%
Total			Count	150	187
			% within Direction	100.0%	100.0%

### Plant Foot Direction

The direction of the plant foot as a significant predictor of shot direction, Chi-square ( $N=337$ ,  $df=2$ ) = 194.25,  $p<.001$ . Table 6 shows the predictive percentage of direction of the plant foot and shot direction. The plant foot pointing to the right shows a stronger prediction that the shot will go the goalkeeper's right. The plant foot pointing left shows a stronger prediction that the shot will go to the goalkeeper's left. The plant foot pointing straight shows a stronger prediction that the shot will go goalkeeper's right.

Table 6

*Plant Foot by Shot Direction*

			Direction		Total
			Right	Left	
Plant Foot Direction	Right	Count	60	0	60
		% within Direction	40.0%	.0%	17.8%
	Left	Count	9	147	156
		% within Direction	6.0%	78.6%	46.3%
	Straight	Count	81	40	121
		% within Direction	54.0%	21.4%	35.9%
Total	Count		150	187	337
	% within Direction		100.00%	100.00%	100.00%

### Off-Arm Action

The action of the off-arm is a significant predictor of shot direction, Chi-square ( $N=337$ ,  $df=2$ ) = 97.15,  $p<.001$ . Table 7 shows the predictive percentage of off-action arm movement and shot direction. The arm staying down shows a stronger prediction that the shot will go the goalkeeper's left. The arm moving up shows a stronger prediction that the shot will go to the goalkeeper's right.

Table 7

*Off- Action Arm by Direction*

			Direction		Total
			Right	Left	
Arm action	Down	Count	18	122	140
		% within Direction	12.0%	65.2%	41.5%
	Up	Count	132	65	197
		% within Direction	88.0%	34.8%	58.5%
Total		Count	150	187	337
		% within Direction	100.0%	100.0%	100.0%

**Discussion**

The purpose of this study was to use direct observation methods to collect evidence of pre-impact cues in a soccer penalty kick and to analyze their predictive powers in determining shot direction. The five pre-impact cues were position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. The principal results show that the pre-impact cues hold anticipatory value of indicating shot direction in a soccer penalty kick. Logistic regression analysis of the five pre-impact cues revealed that the alignment of the hips and trunk lean were significant ( $p < .001$ ). Chi-square analysis of each cues separately revealed that each were a significant indicator of shot direction ( $p < .001$ ).

The findings of this study were based on direct observation methods, and generated scientific values of the significances for the pre-impact cues in indicating penalty shot direction. These findings are an essential addition to the literature because the previous studies merely reported cues without giving much attention to the scientific values of each pre-impact cue. Studies relying heavily on self reporting and post-hoc



interview (McMorris et al., 1993; McMorris et al., 1995; Williams & Burwitz, 1993) as a single method of collecting cue information, may contaminate results based on the players' own biases and expectations (Abernethy, 1991). Kim and Lee's (2006) use of an eye movement tracking system to track the gaze patterns of soccer goalkeepers in successful defense of penalty produced kicks zones of interest related to the athlete's line-of-sight and revealed only general information not specifically what the athletes were seeing (Abernethy, 1991). The use of direct observation methods adds validity to the pre-impact cues that were reported in previous studies. Direct (systematic) observation has been used in the study of human behavior in natural settings, including physical activity (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Chow, McKenzie, & Louie, 2008). The findings of this study show that direct observation methods are relevant collection procedures in the athletic research field.

A secondary aim of this study was to determine the predictive power of each pre-impact cue. The findings revealed that each pre-impact cue by itself was a significant indicator of shot direction ( $p < .001$ ). These findings support and provide a base scientific value for each cue that was reported in previous research: starting position and position of the approach run (Franks, McGarry, & Hanvey, 1999; McMorris, Copeman, Corcoran, Saunders, & Potter, 1993; McMorris et al., 1995; Williams & Burwitz, 1993; Williams & Griffiths, 2002), angle of the hips before impact (Williams & Burwitz, 1993), angle and lean of the upper body trunk, (Franks et al., 1999; McMorris et al., 1993; & McMorris, & Hauxwell, 1995), shoulder zone (Kim & Lee, 2006), and non-kicking leg and plant foot (Franks et al., 1999; Kim & Lee, 2006).

The findings in this study also support the suggestion that the pre-impact cues may be related to each other. Williams and Griffiths (2002) study expressed a relationship between two pre-impact cues; they stated that the position of the approach run contributed to the alignment of the hips. In this study the logistical regression analysis revealed that the alignment of hips and the trunk lean were the significant predictors at  $p < .001$ , but chi-square analysis of each cue revealed that independently they were significant indicators of shot direction ( $p < .001$ ). Therefore, it is concluded that the five pre-impact cues may be co committal. The logistic regression analysis results of alignment of hips and trunk lean being significant supports occlusion point research stating that the strongest predictors happen closest to the point of impact (McMorris et al., 1993; McMorris et al., 1995; McMorris & Colenso, 1996). The findings lead the researcher to conclude that the practical importance of the pre-impact cues may be related to the time frame and order in which they appear in the soccer penalty kick.

### **Practical Application**

Designing a practical goalkeeping training regimen from this study could be built around an understanding that merely guessing sides isn't the better option, when a pre-impact cue indicates shot direction with more than 50% accuracy. By following the information in Table 8, coaches can begin teaching goalkeepers what pre-impact cues to look for and what they indicate. The strategy would be to teach the goalkeepers how to recognize each pre-impact cue and when they will be appearing during the shot sequence. Expert goalkeepers narrow their focus on as few indicators as possible (Savelsbergh, Williams, Van Der Kamp, & Ward, 2002; Williams & Burwitz, 1993). The coaches should encourage the keepers to recognize how each pre-impact cue is related. Tactical

coaching points would stress that acting too early could allow a shooter to react to the goalkeepers' movement, but waiting too late will not allow enough time to complete a diving motion.

Table 8

*Cues by Direction*

	Shot Direction	
	Left	Right
Position of Approach Run	Wide	Direct
Arm Action	Down	Up
Plant Foot	Left	Straight Right
Trunk Lean	Back	Forward
Alignment of the hips	Open	Closed

*Note. Directions are from the goalkeeper's point of view.*

*Pre-impact cues appear in the table in sequential order of occurrence during a penalty kick.*

**Preparing the Goalkeeper to deal with penalty kicks.**

Using video based training methods is an excellent way to begin preparing goalkeeper to deal with penalty kicks. McMorris and Hauxwell (1995) conclude that video observation of penalty kicks can improve novice goalkeepers' ability to anticipate shot direction, but there is little advantage in viewing a large quantity. Using videos of penalty kicks can train the goalkeeper to tactically recognize pre-impact cues, but Barry (1997) indicates that there are technical and psychological approaches to consider too. The goalkeeper must work on diving techniques. The coach must prepare the athlete to handle, deflect and punch balls struck low and to the corners. The coach must hold the

keepers responsible for the penalty kick goals. The odds are in favor of the kicker, but the goalkeeper should always be encouraged to strive to bring the save percentage up.

### **Limitations of the Study**

The collection of the anticipatory cues was done in a laboratory environment instead of game situation whereas cameras were in plain sight of the participants. Each shot was directed by the researcher which may have influenced the intensity and accuracy of the shot; the researcher did not take into account which side was preferred by the kicker. Statistical information of each participant was not collected in the study (i.e. height, weight, age, etc.). The lack of this information influences the ability to generalize to specific populations. Statistics regarding the relationship between the pre-impact cues were not analyzed. This would have added to the results of the study.

### **Future Research**

Although there is enough data to create a coachable set of pre-impact cues for goalkeepers, a natural progression from this study would be to include female participants, and also observing left-footed players. The more this study is replicated the more reliable the pre-impact cues become and new pre-impact cues may be realized.

The researcher recommends that penalty kicks become documented statistics in high school soccer. Currently it is not kept by the Mississippi High School Activities Association or the National Federation of State High School Association. Most penalty kick statistics available for reference pertains to high level professional and world class competitions. Having skill level appropriate statistics would provide a more accurate account of a soccer penalty kicks and everything that pertains to them.

Collecting video evidence of penalty kicks from a real game situation would eliminate the limitation of trying to duplicate game intensity in a lab setting. Analysis of actual evidence of pre-impact cues during free play penalty kicks and game deciding penalty shoot-outs would produce the best information and ultimately affect the goalkeeper's ability to perform in those situations.

### **Conclusion**

Since the adoption of the penalty kick rule in 1891, the penalty kick has grown in importance in the game of soccer. FIFA first established the penalty kick shoot-out to decide its 1982 World Cup. Shoot outs are now a deciding factor in ending tied competitions from professional to youth soccer. The success rate significantly favors the shooter, but elite goalkeepers are using pre-impact cues to close the gap. Research on pre-impact cues of penalty kicks has already resulted in a FIFA rule change, allowing the goalkeepers to now move laterally on the line before the ball is kicked. Existing research reported pre-impact cues; however, methods used to attain them created issues of reliability. This study used direct observation methods to generate scientific data to support the reported cues. The purpose of the study was to provide operational definitions, collect contextual rich data, and standardize the data analysis of each pre-impact cue resulting in statistical evidence of the predictive power in indicating shot direction. The five pre-impact cues examined in the study were the position of the approach run, alignment of the hips, lean of trunk, placement of non-kicking foot, and action of the non-kicking side arm. These five pre-impact cues hold anticipatory value of indicating soccer penalty shot direction. The alignment of the hips and the trunk lean held significant predictive power ( $p < .001$ ). Each pre-impact cue analyzed separately

significantly indicated shot direction ( $p < .001$ ). The results have both scientific value and practical implications. Further research can build on the findings and operational definitions adapting and testing them with other sample groups, while practitioners can begin to build technical and tactical plans to teach the pre-impact cues to goalkeepers. Direct observation methods can also be applied to other sports and sport skills.

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## CHAPTER V

## MANUSCRIPT TWO:

## GENERATING ANTICIPATORY CUES USING DIRECT OBSERVATION

## METHODS: FOLLOWING A SOCCER PENALTY KICK MODEL

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**Key words:**

Anticipatory Cues, Dartfish™, Direct Observation, Penalty Kick

### **Abstract**

Anticipatory cues are used in a variety of sports where time constraints and opponents actions are external stimuli that influence the outcome of the event. Identifying correct, accurate and reliable anticipatory cues is a difficult task. Identifying the sport skill, reviewing existing research, and gathering operational definitions are the starting points for teaching anticipatory cues. Following a direct observation model would allow coaches to generate anticipatory cues for a specific sport skill. The purpose of this article is to provide coaches with a description of direct observation methods, and to demonstrate how to generate sport specific anticipatory cues, using soccer penalty kicks as an example.

## **Introduction**

Sport skills can be broken down into two distinct categories: reaction-based sports and non-reaction based sports (Wang, 2009). Reaction sport skills include hitting a baseball, returning a serve, blocking a scoring opportunity, etc., while non-reactive sport skills include putting, picking up a seven-ten split, pole vaulting etc. Reaction based skills are unique in that they happen within a competition between opponents, where time constraints play a huge role. The athletes make decisions based on stimuli in their observable environment such as an upcoming breaking ball or an opponent shooting or dribbling (Wang, 2009). The external stimuli include everything that is taking place before and during the skill. If the stimuli can be recognized and acted upon earlier to predict the outcome, then it becomes an anticipatory cue. According to Abernethy (1991), successful athletes rely on a small set of anticipatory cues, or pre-impact cues, which happen early in an event sequence that predicts the ultimate outcome.

It is imperative that coaches provide correct, accurate and reliable cues to their athletes. Teaching incorrect cues is not only a waste of time, but could cause players or teams to perform poorly. Coaches should do their homework thoroughly before teaching anticipatory cues to athletes. The purpose of this article is to provide coaches with a description of direct observation methods, and to demonstrate how to generate sport specific anticipatory cues, using soccer penalty kicks as an example.

## **Direct Observation**

Direct observation methods are used to study occurrences in a natural setting (Hartman, 1982) and have been used to conduct research in physical activities (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Chow, McKenzie, &

Louie, 2008). The analysis of physical activities using direct observation provides rich contextual information (McKenzie, 2002). In sports, observations that occur during an actual athletic context produce results that are valid in that environment and situation. Direct observation methods allow the observer to classify physical activity and behavior into categories that can be further analyzed in greater detail (McKenzie, 2002). As with any collection procedure there are advantages and disadvantages; Black (1999) indicates that direct observation can be time and labor intensive, but technological advances allow the observations to be recorded with video cameras then stored and analyzed using computers. Direct observation methods can generate data of anticipatory cues by following a few key elements: instrumentation, collection procedures and outcome variables which will be discussed subsequently.

### **Instrumentation**

Direct observation is a process for generating data, not just a single technique or instrument (McKenzie, 2002). Coaches should first identify the specific sport skill and understand the parameters of how, where and when it occurs. For example, in a soccer penalty kick, understanding of the rule is critical. According to the governing body of soccer, the Federation of International Football Association (FIFA) the rules of a penalty kick are as followed:

During a penalty kick the goalkeeper must be on the goal line, facing the kicker, between the posts until the ball is kicked from a distance of 12 yards. The keeper has the ability to move laterally, but must not encroach forward off the line until the ball is struck. The shooter is identified and all players must be at least ten yards from and behind the ball. (2009, pg.41)

Coaches should also gather as much existing information on the sport skill and begin compiling possible anticipatory cues. To find out relevant cues, coaches can examine information from personal experience, peers, or published research; while being cognizant of the source and credibility of the information. Personal experience and peer information are probably the easiest to acquire, but may not be the most reliable methods. Personal experience is a great starting point and peers may have the best of intentions; however, everyone is subject to their own predisposed biases (Abernethy, 1991). Published research is another outlet to find anticipatory cues for a sport skill. There are countless coaching references and also scientific journal articles. However, just because it is print does not necessarily mean that it is correct information. Typically scientific journal articles can be the most reliable source of information due to the peer review process. When reading literature, it is important to critically look at what methods the author(s) used to determine the anticipatory cues. These are a few different ways to get information, but using a combination of them all may be the best approach.

### **Developing operational definitions.**

After collecting and reviewing all the crucial information, the next step is to compile a list of common variables that may help define the anticipatory cues for the sport skill that can be directly observed from the chosen vantage point. Generating operational definitions of the anticipatory cues is crucial for reliable results, as they provide detailed criteria of how to analyze the data. Operational definitions should be developed for each anticipatory cue, providing detailed criteria of how to analyze the data. The operational definitions cover what anticipatory cue is being measured, when or where it is occurring, and how it is classified. For example, after reviewing the existing

data on penalty kicks and determining that the observations will be from the goalkeeper's point of view, the researcher created five operational definitions of anticipatory cues in a soccer penalty kick.

### **Operational definitions of anticipatory cues in a soccer penalty kick.**

1. Action of non-kicking side arm: Action on the non-kicking side arm refers to the position of the kicker's left arm. The measures are taken during the final stages of the approach run coinciding with the last plant foot step. The measures are classified as either up (i.e. quick and deliberate left arm movement extended to the side and hand raised above the waist) or down (i.e. arm stays close to the body and hand remains lower than the waist).
2. Position of the approach run: Position of the approach run refers to the kicker's position relative to the ball at the point when the kicker begins to move towards the ball. The measures are classified as either direct (i.e. within three steps to the left of the ball) or wide (i.e. greater than three steps to the left of the ball).
3. Alignment of the hips: Alignment of the hips refers to the alignment of the kicker's hips starting just before ball contact and finishing at ball contact. The measures are classified as either open (i.e. hip alignment is not becoming parallel with the goal line) or closed (i.e. hip alignment is or is becoming parallel to goal line).
4. Lean of trunk: The lean of trunk refers to the kicker's upper body position in relationship to the ball at or immediately before contact. The measures are classified as either forward (i.e. head and upper body is leaning forward over the ball) or back (i.e. head and upper body is leaning back and away from the ball).
5. Placement of non-kicking foot: Placement of the non-kicking foot refers to the kicker's left foot, (i.e. plant foot). The measure is taken of the direction of the toe on the last left footed step before impact. The measure of the plant foot is classified as left, straight or right.

### **Collection Procedures**

Achieving accurate data with direct observation methods calls for attention to detail (McKenzie, 2002). Planning each phase of the process will help ensure that the data can be collected accurately and reliably every time. Now that the anticipatory cues

are defined the next step is to decide which athletes to observe, when to observe, and how to observe.

### **Participants.**

Choosing the correct participants is an important aspect in determining the generalization of the pre-impact cues. Follow all necessary guidelines for acquiring permission from the athletes, guardians and proper authority before beginning observation; especially when videotaping minors. It is important to recognize the individual variables among participants and group them accordingly i.e. male and female, right-handed and left-handed, beginner and expert, etc. Choose a good participant representation who will relate well to the athletic population of interest.

### **Procedures.**

Observation procedures may also be influenced by other variables such as playing surface, weather, athlete fatigue, camera distractions, etc. Understanding and accommodating as many variables as possible will also add strength to the results. Planning methods for when and how to conduct the observation is a crucial step. The methods should be clear and repeatable. Coaches should be creative and adapt vantage points that fit the most practical position for observation of the anticipatory cues. Using video cameras to record the observations produce a permanent sample that can be transferred to a computer, viewed as many times as needed, by different people, and in a less distracting environment. However, using video cameras requires time to set up, can be costly to replace if damaged, and may cause athletes to react differently when being videotaped (McKenzie, 2002). As a practical example a pilot study was designed to



video cameras to observe soccer penalty kick anticipatory cues of male right-footed high school soccer players.

### **Collection procedures of penalty kick anticipatory cues.**

Two cameras (Cannon Digital Video Camcorder NTSC Optura 10) mounted on tripods were used to observe kickers taking penalty kicks to the right and left sides of the goal. Camera One (see Figure 1) was set on the goal line to record the actions of the kicker and Camera Two was set at the top of the penalty arc behind the kicker to record the shot direction. Cameras were set to the height of 70 inches to reflect the viewpoint of a keeper.



Figure 1. Camera One Position

The participants were two male right-footed high school soccer players from the same team, selected by their coach as the top two right-footed penalty takers on the team. The observations occurred on the participants' practice/game field. The researcher allowed about fifteen minutes preparation time to set up the cameras and mark of the appropriate penalty shot distance. The participants warmed up to ensure that there were no injuries and the researcher encouraged taking practice penalty kick shots with the

tripod in position to get the participants familiarized to the position of Camera One.

Before the data was collected Camera One was placed on the tripod.

The participants were given instructions to kick the ball at game speed to one of three options, either left, right or kicker's choice. The researcher provided regulation (size five) soccer balls and directional shot instructions for each shot sequence. The shot sequence protocol was the same for each shot: the participant was given the ball and direction for the shot; the participant then placed the ball on the penalty mark and placed the kick; and the ball was retrieved from the goal. The participants were instructed to shoot an equal number of times to each side and two kicker's choice options following a pre-set shot order.

### **Outcome Variables**

The next step is to code or analyze the data. Coding the variables begins with editing the video into clips including only the necessary components set in the operational definitions of each anticipatory cue. The clips must include the movement patterns of the sport skill right up to the point of impact. Strategies should be adopted to strengthen the reliability and validity of the coding. By editing the video clips to the point of impact the coder should not be aware of the outcome; knowing the outcome could create coding bias and yield results that are not reliable. While identifying the outcome is a crucial element in determining anticipatory cues, the only information that should be used is the edited video clips and the operational definitions.

There is computer software that can help with the process of collecting, storing, coding, and presenting observational data. Dartfish™ computer software is an affordable and user friendly option. Dartfish™ can be extremely useful in direct observation studies

because of the many functions that allow the user to archive the video and any analyses. Using video software also reduces chances of losing data, and gives the researcher high video quality. There are different versions of Dartfish™ software available to fit the budget and meet the needs of many circumstances ([www.dartfish.com](http://www.dartfish.com), n.d.).

### **Dartfish™ instrumentation used in coding anticipatory cues in soccer penalty kicks.**

The researcher used Dartfish™ Team Pro version with the capability of video replay, drawing tools and tagging panels. The video replay function allows the clips to be edited and watched in changeable speeds or a frame at a time without losing any video quality. Drawing tools were also used to give the researcher a criterion for coding missed shots. The tagging function is ideal for coding observational data because it allowed the researcher to classify clips into categories that were further analyzed in greater detail. Dartfish™ tagging is versatile because it allowed the user to create customized tagging panels that fit the necessary variables to code anticipatory cues in the soccer penalty kick. By clicking the appropriate buttons Dartfish™ kept track of the prevalent pre-impact cues for each clip and created a spreadsheet of the data.

### **Reliability of the anticipatory cues.**

Whichever option chosen for coding the result should provide a list of variables and outcomes. The next goal is to examine the reliability in classifying the pre-impact cues. Direct observation research provides data from an actual setting and is useful to researchers and practitioners; however, the data is only useful if the instrumentation is both valid and reliable. Observation is a direct measure of behavior and as long as the operational definitions used to code are adhered to, there is little room for interpretation

(McKenzie, 2002). Reliability in observational research refers to the consistency of coding among trained researchers. Inter-rater reliability can be achieved by comparing percentages of coding agreement between two observers viewing the same participants and occasion. The results will show how reliable the operational definitions are and areas where they may need to be revised.

### **Reliability of the anticipatory cues in the soccer penalty kick.**

Reliability of the instrument was tested by teaching another rater to code the data. The researcher provided operational definitions and demonstrated how the Dartfish™ tagging panel worked. This took about thirty minutes. The rater then coded the data independently. Below is the agreement percentages of each anticipatory cue (see Table 1) and the raw data by each coder (see Table 2).

Table 1

#### *Agreement of Anticipatory Cue by Percentages*

Cues	Position of the approach run	Trunk lean	Alignment of the hips	Direction of plant foot	Arm action
Inter-rater reliability percentage	62.50%	50%	87.50%	81%	100%

Table 2

*Raw Data of Coding Anticipatory Cues from Each Coder*

PLAYER	SHOT	SHOT DIRECTION	ANGLE OF APPROACH	TRUNK LEAN	ANGLE OF HIPS	PLANT FOOT	ARM	RATER
1	1	RIGHT	DIRECT	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	2	LEFT	WIDE	FORWARD	CLOSED	LEFT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	3	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	2
	4	LEFT	DIRECT	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	2
	5	RIGHT	DIRECT	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	6	RIGHT	DIRECT	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	7	RIGHT	DIRECT	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	8	RIGHT	WIDE	FORWARD	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
2	9	LEFT	DIRECT	FORWARD	CLOSED	LEFT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	10	LEFT	WIDE	BACK	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	CLOSED	LEFT	EXTENSION	2
	11	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	OPEN	LEFT	EXTENSION	2
	12	LEFT	WIDE	FORWARD	CLOSED	RIGHT	EXTENSION	1
		LEFT	WIDE	BACK	OPEN	LEFT	EXTENSION	2
	13	RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	2
	14	RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	FLEXION	2
	15	RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
	16	RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	1
		RIGHT	WIDE	BACK	OPEN	RIGHT	EXTENSION	2
			62.50%	50%	87.50%	81%	100%	

The reliability test of the anticipatory cues in the soccer penalty kick confirms that the pre-impact cues were prevalent in the video clips. More specifically the results showed that the trunk lean cue was not consistently coded. This is an important cue in the literature but was very hard to determine from this camera position. The position of

approach run had a low inter-rater percentage; however the researcher modified the operational definition to give a more consistent meaning of direct and wide. Direction of the plant foot was coded with measure of left and right, after discussing the operation definition with the second coder the researcher added a third position of straight. Not only did running an inter-rater reliability test point out the inconsistency of the trunk lean, it led to strengthening the operational definitions of the other anticipatory cues.

### **Summary**

Identifying the problem, gathering existing data and defining the cues to be studied is the basic beginning to conducting pre-impact cue research. Following the instructions in the article and the penalty kick model, direct observation of pre-impact cues in a practical setting can be translated to any sport skill. The coach must be creative and adapt camera positions that fit the most practical point of view for their sport. Dartfish™ computer software is an excellent tool to analyze the data because of its availability and user friendly design. There are many different sports that would benefit from knowing proper anticipatory cues. Using this method of data collection should enhance the process of identifying correct, accurate and reliable anticipatory cues. The anticipatory cues are now available for further investigations across different athlete populations. The ultimate goal of identifying anticipatory cues of a sport skill is to translate the information into practical coaching points.

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## **Addendum**

### ***Direct Observation***

- Direct observation is a process for generating data, not just a single technique or instrument (McKenzie, 2002).
- Coaches should first identify the specific sport skill and understand the parameters of how, where, and when it occurs.

### ***Ways to Gathering Existing Data***

- Personal experience
- Learning from peers
- Published research

### ***Developing Operational Definitions.***

- Compile a list of common variables that may help define the anticipatory cues for the sport skill.
- Use only the relevant anticipatory cues that can be directly observed from the chosen vantage point.
- Operational definitions should be developed for each anticipatory cue, providing detailed criteria of how to analyze the data.
- The operational definitions cover what anticipatory cue is being measured, when or where it is occurring, and how it is classified.

### ***Collection Procedures***

- Achieving accurate data with direct observation methods calls for attention to detail (McKenzie, 2002).
- Planning each phase of the process will help insure that the data can be collected accurately and reliably every time.

### ***Participants***

- Follow all necessary guidelines for acquiring permission from the athletes, guardians and proper authority before beginning observation; especially when videotaping minors.
- It is important to recognize the individual variables among participants and group them accordingly i.e. male and female, right-handed and left-handed, beginner and expert, etc.
- Choose a good participant representation that will relate best to the athletic population of interest.

### ***Methods***

- Observation methods may also be limited by other variables such as playing surface, weather, athlete fatigue, camera distractions, etc.



- Understanding and accommodating as many variables as possible will also add strength to the results.
- The methods should be clear and repeatable.
- Coaches should be creative and adapt vantage points that fit the most practical position for observation of the anticipatory cues.

#### ***Outcome variables***

- Coding the variables begins with editing the video into clips including only the necessary components set in the operational definitions of each pre-impact cue.
- The clips must include the process of the sport skill right up to the point of impact.
- While coding, adhere firmly to the operational definitions.
- Dartfish™ is an extremely useful tool in direct observation studies because of the many functions that allow the user to archive the video and any analysis done to it.

#### ***Reliability of the pre-impact cues***

- Inter-rater reliability can be achieved by comparing percentages of coding agreement between two observers viewing the same clips and using the same operational definitions.
- The results will show how reliable the operational definitions are and areas where they may need to be revised.